Discrepancies between lung function and asthma control: Asthma perception and association with demographics and anxiety

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ABSTRACT

Understanding asthma symptom perception is necessary for reducing unnecessary costs both for asthma sufferers and society and will contribute to improving asthma management. The primary aim of this study was to develop and test a standardized method for classification of asthma perceiver categories into under-, normal, and overperceiver groups based on the comparison between self-report and lung function components of asthma control. Additionally, the degree to which demographic variables and anxiety contributed to the classification of patients into perceiver groups was examined. Patients underwent methacholine or reversibility testing to confirm asthma diagnosis. Next, participants completed lung function testing over 3 days before their next appointment. Finally, patients filled out demographic and self-report measures including the Asthma Control Test (ACT). Each self-report category of control assessed by the ACT (interference, shortness of breath, nighttime awakenings, rescue inhaler usage, and a composite total score) was compared with lung function measurements using a modified version of the asthma risk grid. Using the modified asthma risk grid to determine perceiver categorization, this sample included 14 underperceivers, 29 normal perceivers, and 36 overperceivers. A discriminant analysis was performed that indicated that a majority of underperceivers were characterized by being African American and having low asthma-specific anxiety. Normal perceivers in this sample tended to be older. Overperceivers tended to be female. Our findings encourage further research using the reported method of classifying asthma patients into perceiver categories.

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Despite advances in asthma medication, inpatient hospital services still account for the most sizable portion of >$20 billion in asthma-related costs.[1] One reason for high hospitalization costs is patients who have difficulty perceiving when their asthma symptoms are indicative of a dangerous airway status.[2] Underperceivers have a blunted awareness of asthma symptoms in relation to deteriorations in lung function; these individuals have an increased risk of hospitalizations and fatality. Overperceivers have an exaggerated awareness of changes in their airway states leading to overuse of emergency services[2] and side effects from overuse of medication.[3] Obtaining a better understanding of asthma perception is important for reducing unnecessary costs for asthma suffers and society and will contribute to improving asthma management.

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A standardized method of assessing the accuracy of asthma perception is lacking. One suggested method involves comparing self-report of symptoms with pulmonary function tests.[4] However, because the comparison is not made on a particular scale or by using standardized guidelines, the determination of patients' perceiver status is arbitrary depending on the specific sample.[5] An alternative method is the asthma risk grid,[6,7] which contrasts actual lung function measurements on the horizontal axis with patients' estimate of their lung function on the vertical axis. However, patients' estimations could simply capture the ability to guess their lung function and at best may only inform about one aspect of the patients' self-perceived asthma status. An adaptation is needed that combines the strengths provided by both methods in a standardized way.

The proposed method entails using the asthma control designations of well controlled (WC), not well controlled (NWC), or very poorly controlled (VPC), from current guidelines,[8] to quantify self-report and lung function on the same scale. Previous research has shown inconsistency between patients' perceptions of dyspnea and lung function.[2,9] Currently, the determination of asthma control is based on the most severe categorization,[8] with no consideration of discrepancy between self-report and lung function. However, because such discrepancies are the foundation underlying perceiver classification,[5] it may be correlated with clinically meaningful outcomes and thus deserve further evaluation.

Patients' anxiety levels are among the chief candidates for predictors of overperceived or underperceived asthma. High levels of general anxiety are associated with report of more asthma symptoms, more frequent medical service trips, and increased medication use;[10] possibly indicating that high anxiety could predict overperception. Low general anxiety is associated with an exaggerated confidence in personal abilities to control asthma, thus leading to increased hospitalization because symptoms can reach dangerous levels before emergency measures are taken.[11] This may suggest that low anxiety could predict underperception.

The primary aim of this cross-sectional study was to develop and test a standardized method for classifying asthma perception by using an adapted asthma risk grid, which compares lung function with self-report components of asthma control. In addition, we sought to investigate the degree to which high or low levels of anxiety symptoms were associated with this classification. The contribution of demographic variables to classification status was also examined given that prior research has found that gender,[12] age,[13] and race[14] were associated with aspects of airway perception.

METHOD

Work was performed at the Martha Foster Lung Care Center at Baylor University Medical Center and the Stress, Anxiety, and Chronic Disease Research Center in the Department of Psychology at Southern Methodist University.

Participants

Adult asthma patients ($n = 90$) were recruited from outpatient asthma clinics (31.1%), online websites (17.8%), community flyers and advertisements placed in local newspapers (30.0%), participation in previous asthma research (11.1%), and referral from friends and family members (6.7%). Recruitment was in the context of a clinical trial investigating the efficacy of breathing training to improve asthma control. Exclusion criteria were a postbronchodilator lung function of <60% of predicted, history of heart disease, stroke, thyroid problems, chronic obstructive pulmonary disease, emphysema, uncontrolled diabetes, tuberculosis, alcohol/substance dependence, bipolar disorder, psychosis, current smoking, ≥10 pack-years of smoking, use of oral or injected corticosteroids in the past 3 months, and actual or planned pregnancy. The study was approved by Baylor Research Institute (008-180) and the Southern Methodist University Institutional Review Board (KS08-051); all participants provided informed consent.

Instruments and Measures

Lung Function. Forced expiratory volume in the 1st second (FEV_1) was measured in the laboratory and during patients' daily lives. Under laboratory conditions, FEV_1 was measured during methacholine provocation with a KoKo DigiDoser PFT Spirometer (Ferraris-PDS CardioRespiratory, Louisville, CO). Because a limitation of previous research was the sole reliance on laboratory lung function assessment,[5] we also measured ambulatory FEV_1 with a handheld electronic spirometer (AM2+; CareFusion/Jaeger, Hochberg, Germany) across 3 days with six daily measurements (after waking, 11 A.M.–12 P.M., 2–3 P.M., 5–6 P.M., 8–9 P.M., and before bed). Compliance with this protocol was good with an average of 15.2 (SD = 4.2) completed assessments. FEV_1 was averaged and values were expressed as percent of predicted.

Methacholine testing was performed according to American Thoracic Society guidelines.[15] Methacholine chloride was administered using a dosimeter (nSpire; Health, Ltd., Hertford, U.K.) attached to the KoKo spirometer. A 20% drop in FEV_1 was considered a positive response. If initial FEV_1 was <60% of predicted, reversibility testing, determined by a ≥12% increase in FEV_1, was performed as an alternative.[16]

Self-Report Measures

The Asthma Control Test.[17] The Asthma Control Test (ACT) is a five-item self-report instrument developed to parallel the National Heart, Lung, and Blood Institute[8] guidelines of asthma control. Each item refers to one of the relevant self-report facets[17] and is on a 5-point scale (total score, 5–25; higher scores indicate greater control).

The Asthma Symptom Checklist.[18,19] The panic–fear subscale of the Asthma Symptom Checklist (ASC) explores how often anxiety symptoms are experienced during an asthma attack. The subscale consists of eight symptoms (*e.g.*, "worried about an attack" and "panicky"). Each item is rated on a 5-point scale from *never* to *always* (0–4).

Hospital Anxiety and Depression Scale.[20] The Hospital Anxiety and Depression Scale (HADS) has two seven-item subscales measuring anxious and depressed mood in a chronically ill patient population. Cutoff scores for both subscales are 0–7, no clinical relevance; 8–10, likely clinical significance; and 11–21, clinical significance.[21]

Table 1 **Control designations based on responses to the ACT**

ACT Question	Response	Control Designation
How much of the time did your asthma keep you from getting as much done at work, school, or at home?	None of the Time	WC
	Some of the time or a little of the time	NWC
	All of the time or most of the time	VPC
How often have you had shortness of breath?	Once or twice a week or not at all	WC
	Once a day or 3–6 times a week	NWC
	More than once a day	VPC
How often did your asthma symptoms wake you up at night or earlier than usual in the morning?	Once or twice a month or not at all	WC
	Once a week or 2 or 3 nights a week	NWC
	≥4 nights a week	VPC
How often have you used your rescue inhaler or nebulizer medication?	Once a week or less or not at all	WC
	2 or 3 times per week	NWC
	1 or 2 times per day or 3+ times per day	VPC
ACT total score	>20	WC
	16–19	NWC
	<15	VPC

Note: Developed from the ACT.[17]
ACT = Asthma Control Test; WC = well controlled; NWC = not well controlled; VPC = very poorly controlled.

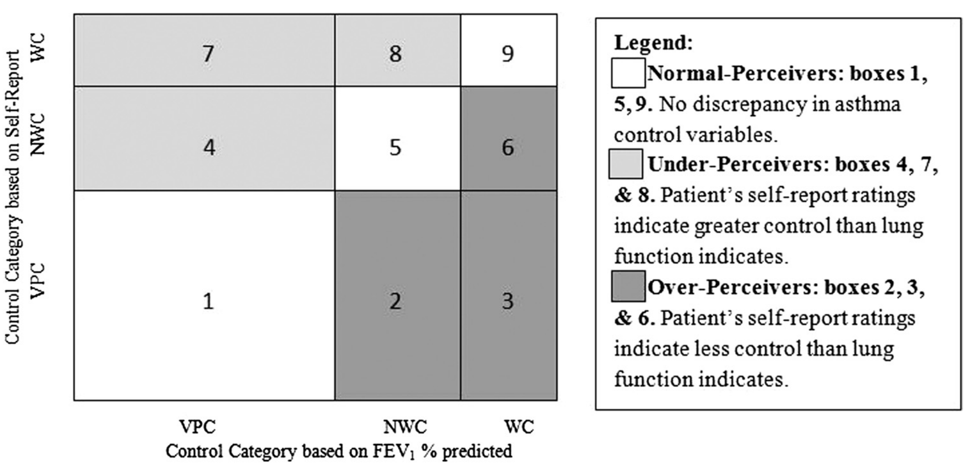

Figure 1. *The modified version of the asthma risk grid (adapted from Ref. 7) using control category designations to determine asthma perceiver categories. WC, well controlled; NWC, not well controlled; VPC, very poorly controlled.*

Procedure

After signing consent, patients underwent a medical exam with asthma history by a pulmonologist. A respiratory technician then performed spirometry and the methacholine test. Eligible patients were then trained in self-assessment of lung function with the AM2+. The patients then monitored their lung function for 3 days. Data were downloaded from the AM2+ on the second visit and the patient completed the self-report measures. A $25 travel and time reimbursement was provided.

Modification of the Asthma Risk Grid. The original asthma risk grid established danger, accurate, and symptom magnification zones.[6,7] In the modified version these zones corresponded with the asthma under-, normal, and overperceiver categories. The three categories of asthma control from the National Heart, Lung, and Blood institute[8] guidelines were used to scale the horizontal and vertical axes of the risk grid. Classification of FEV_1% of predicted formed the horizontal axis (80–100%, 60–79%, and <60%) and classifications of control by the ACT formed the vertical axis. Items 1–4 measure interference with daily life, shortness of breath, frequency of nighttime awakening, and frequency of rescue inhaler or nebulizer medication use, respectively, in the past month. Item 5 is a global rating of asthma control. The total of all five items can range from 5 to 25 and forms the final self-report component of control (Table 1). This allowed for a direct comparison of lung function and symptom perception using the same scale (Fig. 1). An accurate, normal perceiver was someone whose self-ratings placed them in the same category of control as their FEV_1 (WC and 80–100%, NWC and 60–80%, VPC and <60%, for self-report and lung function). On the other hand, patients were classified as overperceivers if their self-ratings placed them in a lower control category than their lung function measurement. Finally, patients were classified as underperceivers if their self-ratings placed them in a higher control category than their lung function.

Data Analysis

Issues of power are the same as for a multivariate analysis of variance, *a priori* power analysis using G*Power 3.1.2 indicated that for a medium effect ($f^2[V]$ = 0.25) at significance level of $\alpha = 0.05$ and power of β = 0.8 a total sample size of 68 was needed.[22]

To assess the consistency with which patients were classified into the same perceiver category depending on the ACT self-report component used, internal consistency was calculated by Cronbach's α and the mean item intercorrelation. This analysis was conducted with 89 of the 90 participants, because 1 person failed to complete all items on the ACT.

Univariate analyses of variances were used to examine differences between perceiver groups in age, gender, race, education, income, the ASC panic/fear subscale, the HADS anxiety subscale, and the HADS depression subscale. Discriminant analysis was used to identify linear combinations of these demographic and psychological variables that would maximally discriminate perceiver group membership.[23] The analysis was performed with perceiver categorization based on the ACT total variable as the dependent variable. Because of missing values, 79 of the 90 participants entered this analysis.

Table 2 **Participants' characteristics**

Age (yr, mean ± SD, range)	38.58 ± 12.8, 20–65
Gender (% female)	58.9
Race/ethnicity (%)	
White/non-Hispanic	56.7
Black/non-Hispanic	32.2
Asian	4.4
White/Hispanic	6.7
Education (% college)	87.8
Household income	
<$25,000	20
$25,000–50,999	37.8
$51,000–75,999	17.8
$76,000–100,000	7.8
>$100,000	12.2
Maintenance medication use (%)	56.5
ASC panic–fear subscale (mean ± SD, range)	4.72 ± 4.3, 0–16
HADS, anxiety subscale (mean ± SD, range)	5.33 ± 3.7, 0–16
HADS, depression subscale (mean ± SD, range)	3.67 ± 3.3, 0–13
FEV_1% predicted (mean ± SD, range)	77.68 ± 14.4, 49.19–128.45

Cutoff scores for both HADS subscales are 0–7, no clinical relevance; 8–10, likely clinical significance; and 11–21, clinical significance.[21]
ASC = Asthma Symptom Checklist; HADS = Hospital Anxiety and Depression Scale; FEV_1% predicted = forced expiratory volume in the 1st s percent of predicted.

RESULTS

Participant Characteristics

The sample was diverse with regard to race, household income, and lung function (Table 2), although the education level was relatively high. On average, the sample reported nonclinical levels of anxiety (5.33) and depression (3.67) as measured by the HADS.[20] More specifically, falling into the low range of the HADS were 65 participants' anxiety ratings and 71 participants' depression ratings. In the probable clinical range there were 10 and 8 participants' anxiety and depression ratings, respectively. Finally, 9 participants' anxiety ratings and 5 participants' depression ratings fell in the likely clinical range.

Asthma Perceiver Categorization

Using the modified asthma risk grid, 14 patients were identified as underperceivers (17.7%), 29 as normal perceivers (36.7%), and 36 as overperceivers (45.6%; see Table 3).

Redundancy of ACT Items for Asthma Perceiver Categorization

Internal consistency for perceiver designations was high ($\alpha = 0.88$) and the interitem correlations between the perceiver categorizations by the individual ACT items and the total score were $r_{ii} = 0.61–0.71$ (Table 4). Because categorizations derived from the individual ACT items were largely redundant, the ACT total score (including item 5) was used as the dependent variable in the subsequent discriminant analysis.

Discrimination of Asthma Perceiver Groups by Demographics and Anxiety

African Americans formed the highest percentage in the underperceiver group and the lowest percentage in the overperceiver group (Table 3). Normal perceivers had a higher average age than over- or underperceivers. Overperceivers tended to have the highest percentage of female patients. Underperceivers showed the lowest values in panic–fear.

Table 3 **Tests of equality of group means for the predictor variables in the discriminant function analysis for under- (n = 14), normal (n = 29), and overperceivers (n = 36)**

	Underperceivers (n = 14)	Normal Perceivers (n = 29)	Overperceivers (n = 36)	Group Differences (df = 2, 76)
African American race (%)	57.1	31.0	19.4	$F = 3.57$, $p = 0.033$*
Panic/fear subscale of the ASC, mean (SD)	2.57 (2.7)	5.03 (4.6)	5.50 (4.4)	$F = 2.45$, $p = 0.093$#
Household income (%)				$F = 1.55$, $p = 0.219$
<$25,000	21.4	13.8	25.0	
$25,000–50,999	57.1	37.9	36.1	
$51,000–75,999	14.3	17.2	19.4	
$76,000–100,000	0.0	13.8	8.3	
>$100,000	7.1	17.2	11.1	
Education (% college)	78.6	89.7	86.1	$F = 0.47$, $p = 0.626$
Age, mean (SD)	33.21 (13.4)	44.00 (11.8)	35.89 (12.1)	$F = 5.06$, $p = 0.009$*
Gender (% female)	42.9	55.2	75.0	$F = 0.93$, $p = 0.070$#
HADS, anxiety subscale, mean (SD)	5.79 (4.0)	4.90 (3.7)	5.5 (3.4)	$F = 0.40$, $p = 0.672$
HADS, depression subscale, mean (SD)	4.07 (4.3)	2.97 (2.7)	4.11 (3.5)	$F = 1.02$, $p = 0.365$

*$p < 0.05$.
#$p < 0.10$.
ASC = Asthma Symptom Checklist; HADS = Hospital Anxiety and Depression Scale.

Table 4 **Intercorrelations among the perceiver category designations**

Perceiver category based on	1	2	3	4	5
Interference	1.00	0.628	0.565	0.462	0.635
Shortness of breath		1.00	0.575	0.644	0.660
Nighttime awakening			1.00	0.429	0.610
Rescue inhaler use				1.00	0.713
ACT total score					1.00

n *=89.*
ACT = Asthma Control Test.

Because the goal was to identify the linear combination of anxiety and demographic variables that would maximally distinguish between under-, normal, and overperceivers (k = 3), the discriminant analysis created two function equations ($k - 1$). Wilk's λ was statistically significant for both functions ($\lambda = 0.584$, $\chi^2 = 38.982$, $p = 0.001$, $\eta^2 = 0.416$, and $\lambda = 0.796$, $\chi^2 = 16.519$, $p = 0.021$, $\eta^2 = 0.204$) indicating that both functions were able to discriminate between the three groups. The correlation coefficients (Table 5) indicate the extent to which each variable contributes to the function; factor loadings of 0.30 serve as the cutoff between important and less important variables.[23] For the first function, asthma-specific anxiety contributed most to the distinction between perceiver groups, followed by African American race and trait anxiety. The standardized coefficients for the second function indicated that patients' age and gender contributed most to the distinction between the perceiver groups. The model correctly predicted 63.3% of the perceiver group designations.

DISCUSSION

This study tested a classification system for patients' perception of their asthma status. Misperception of asthma has been linked to adverse asthma management outcomes that are likely to inflate costs of asthma care. Rather than relying on the perception of single aspects of asthma, we used agreed-on aspects of self-

Table 5 **Standardized function coefficients and correlation coefficients for discriminant analysis**

	Function 1		Function 2	
	Standardized Function Coefficients	Correlations between Variables and Discriminant Function	Standardized Function Coefficients	Correlations between Variables and Discriminant Function
African American race	−0.668	−0.427	0.319	0.330
Panic/fear subscale of the ASC	0.969	0.392	−0.226	−0.184
Household income	0.232	0.279	0.212	0.221
Education (college or no college)	0.148	0.179	0.030	0.055
Age (yr)	0.362	0.416	0.780	0.524
Gender	0.006	−0.254	0.748	0.437
HADS, anxiety subscale	−0.590	−0.133	0.152	−0.283
HADS, depression subscale	−0.208	−0.114	−0.325	−0.150

n =79.
ASC = Asthma Symptom Checklist; HADS = Hospital Anxiety and Depression Scale.

reported asthma control and contrasted them with actual lung function using a modified asthma risk grid scheme.[6,7] Indicating the scope of the problem, we found a sizeable portion of patients (63%) falling in categories of over- and underperception, suggesting a discrepancy between their perception of asthma control (measured by the ACT) and actual lung function. Common practice ignores such discrepancies and designates patients according to the aspect of asthma control that indicates the worst clinical status.[8] However, as this study shows, discrepancies between physiological and experiential/behavioral aspects of asthma control are informative for identifying subgroups of asthma patients according to demographics and anxiety levels. The classification scheme could be used to standardize the identification of over- and underperceivers, a problem that has not been solved satisfactorily in current asthma perception research.[3]Over- or underperception of asthma may be key to disease exacerbation risk. Although current research has mostly addressed the standardization of the impairment aspect of asthma control,[24] future research should explore whether the standardization attempt presented here can contribute to a more formal exploration of the at-risk aspect of asthma control and clinical outcomes.

Demographic characteristics were systematically associated with over- or underperception of asthma. A majority of patients in the underperceiver category were African American. This corresponds with previous findings that African American patients misperceive their symptoms during asthma attacks.[25] African Americans receive less consistent care reported by national guidelines regarding inhaled corticosteroid use, asthma action plans, trigger avoidance, and generally receive less specialist care.[26] Lack of symptom awareness may contribute to suboptimal care. The argument could also be reversed such that suboptimal care may contribute to lack of symptom awareness because individuals who receive suboptimal care may be desensitized to the feeling of dyspnea. The direction of this relationship deserves further examination. A recent review found that African Americans using long-acting β-agonists experienced more treatment failures across 10 trials when compared with white Americans.[27] Racial/ethnic asthma differences and disparities are complex; variation in genetic determinants and/or gene–environment interactions may partially explain disparities.[28] There is a clear need for interventions that train the awareness of asthma symptoms and address this disparity in care for African Americans.

Other demographic characteristics that discriminated patients' asthma perceptions were gender and age. Women accounted for 75% of overperceivers, by reporting less asthma control then men for the same level of lung function. This is consistent with findings that women with asthma report higher levels of dyspnea, worse asthma control, and poorer quality of life compared with men with asthma.[12] In part, this may also reflect the general tendency of women to report higher levels of negative affect than men.[29] Another consideration is that because of differences in sex hormones, women are more susceptible to the perception of altered respiratory function than men,' particularly during their reproductive years.[30] Both over- and underperceivers in our sample were younger than normal perceivers. This appears to be at odds with research, suggesting an association between older age and decreases in dyspnea perception.[13] However, this research focused on elderly asthma patients, whereas our sample was with average middle-aged participants.

Discrepancies between lung function and patients' report of asthma control were also associated with asthma-specific anxiety. The panic–fear subscale of the ASC loaded prominently on the first function of the discriminant analysis. Underperceivers tended to show low anxiety regarding symptoms of asthma, which is consistent with previous findings that patients low in panic–fear deny the severity of their asthma.[31] The panic–fear subscale of the ASC could thus be a useful tool for identifying patients that are at risk for underperceiving lung function. On the other hand, high asthma-specific anxiety was not related to overperception in our sample. Previous studies found higher panic–fear scores to be associated with more intensive oral corticosteroid regimens independent of pulmonary function.[32,33] It is possible that these associations were not found because our sample had overall lower levels of panic–fear because of the exclusion of patients with recent oral corticosteroid treatment. Additional stringent inclusion criteria, such as a positive methacholine test, may have removed anxiety patients with vocal cord dysfunction that could be misdiagnosed with asthma.[34,35] However, the influence of anxiety on asthma perception deserves further attention, given that the magnitude of symptom exacerbation is at least partly predicted by emotional factors.[36]

The current study has a number of limitations. It used a convenience sample of patients who volunteered for a treatment study. This may have introduced selection biases that reduce the representativeness for the larger asthma population. For example, underperceivers may have been less likely to seek participation in our study because they would view their asthma as WC and therefore not in need of adjunctive treatment. However, the convergence of our findings with earlier asthma perception research would argue against limited generalizability. Our sample was also restricted in asthma severity. For safety reasons, patients whose laboratory FEV_1 was $<60\%$ of predicted were excluded from participation. In addition, the restriction of oral corticosteroid use excluded the most severe patients that regularly rely on this medication. The overall scores for anxious and depressed mood in our sample were also in a lower range, whereas epidemiological studies suggest an elevated comorbidity of asthma and psychopathology.[37,38] The mean panic–fear subscale score in our sample was below those reported in other studies[19,39]; however, clinical cutoff scores for this scale have not been developed. Nevertheless, the fact that associations with asthma-specific anxiety were found in a sample with restricted severity may indicate the importance of such associations in the general asthma population. Despite possible limitations by our recruitment strategy, the principle and method of the modified asthma risk grid are unaffected by our study sample. Finally, classification success by our discriminant analysis was significant but not all encompassing. However, we used this analytical procedure more for illustrative purposes, suggesting that asthma perceivers as defined by our classification scheme may be different subpopulations that can be distinguished by a linear combination of variables including demographics and anxiety. Studies with more exhaustive lists of predictors that include measures of basic physiological, perceptual (*e.g.*, quality of life), psychophysical, and cognitive processes will be needed to maximally distinguish subgroups of patients.

Over- and underperceivers are likely to require additional medical or behavioral treatment beyond standard guideline-informed care. For example, overperceivers may generalize and catastrophize breathing-related symptoms that originate from anxiety, hyperventilation, or physical activity, and may thus benefit from additional asthma education and behavioral training. Underperceivers may benefit from adjustments in maintenance medication to improve lung function, as well as training to improve symptom perception, which could help them improve awareness of critical disease states. The associated increase in health care costs would be preferable to the cost of hospitalization and the personal cost of the trauma of a severe asthma attack or even death. Future research should investigate to what extent such tailored components of asthma management can improve asthma perception.

Advances in classifying patients' according to ability to perceive their asthma status could help guide physicians' treatment decisions. Determining the level of asthma control has become critical for therapeutic decisions.[40] A standardized method of capturing potential discordances in asthma control parameters by a formal integration of patients' perception or misperception of their disease status may add an important perspective to those decisions. As always, it is important to consider the health care needs of the total patient. This method of determining perceiver status is not meant to solely inform health care decisions but to add to a fine calibration of asthma care that is informed by current guidelines. To avoid ethically problematic medical care decisions, careful consideration of all aspects of patients' disease history, manifestation, and prior treatment is necessary. This is the first article integrating asthma control into a standardized method of determining patients' perceiver status. Our findings encourage additional research into the potential of this classification to predict asthma exacerbation risk.

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REFERENCES

1. National Heart, Lung, and Blood Institute (NHLBI). Morbidity & Mortality: 2009 Chart Book on Cardiovascular, Lung and Blood Diseases. U.S. Department of Health and Human Services, National Institute of Health Web site. Available online at www.nhlbi.nih.gov/resources/docs/2009_ChartBook.pdf; accessed July 20, 2011.
2. Magadle R, Berar-Yanay N, and Weiner P. The risk of hospitalization and near-fatal and fatal asthma in relation to the perception of dyspnea. Chest 121:329–333, 2002.
3. Banzett RB, Dempsey JA, O'Donnell DE, and Wamboldt MZ. Symptom perception and respiratory sensation in asthma. Am J Respir Crit Care Med 162:1178–1182, 2000.
4. Apter AJ, Affleck G, Reisine ST, et al. Perception of airway obstruction in asthma: Sequential daily analyses of symptoms, peak expiratory flow rate, and mood. J Allergy Clin Immunol 99:605–612, 1997.
5. Janssens T, Verleden G, De Peuter S, et al. Inaccurate perception of asthma symptoms: A cognitive-affective framework and implications for asthma treatment. Clin Psychol Rev 29:317–327, 2009.
6. Fritz GK, Yeung A, Wamboldt MZ, et al. Conceptual and methodologic issues in quantifying perceptual accuracy in childhood asthma. J Pediatr Psychol 21:153–173, 1996.
7. Klein RB, Walders N, McQuaid EL, et al. The Asthma Risk Grid: Clinical interpretation of symptom perception. Allergy Asthma Proc 25:1–6, 2004.
8. National Heart, Lung, and Blood Institute (NHLBI), National Asthma Education and Prevention Program. Expert Panel Report 3: Guidelines for the diagnosis and management of asthma (NIH Publication No. 07-4051). U.S. Department of Health and Human Services, National Institutes of Health Web site. Available online at www.nhlbi.nih.gov/guidelines/asthma/asthgdln.pdf; accessed November 12, 2010.
9. Ritz T, Rosenfield D, and Steptoe A. Physical activity, lung function, and shortness of breath in daily life of asthma patients. Chest 138:913–918, 2010.
10. Fernandes L, Fonseca J, Martins S, et al. Association of anxiety with asthma: Subjective and objective outcome measures. Psychosomatics 51:39–46, 2010.
11. Kinsman RA, Dirks JF, Jones NF, and Dahlem NW. Anxiety reduction in asthma: Four catches to general application. Psychosom Med 42:397–405, 1980.
12. Chhabra SK, and Chhabra P. Gender differences in perception of dyspnea, assessment of control, and quality of life in asthma. J Asthma 48:609–615, 2011.
13. Barbaro MP, Lacedonia D, Palladino GP, et al. Dyspnea perception in asthma: Role of airways inflammation, age and emotional status. Respir Med 105:195–203, 2001.
14. Fritz GK, McQuaid EL, Kopel SJ, et al. Ethnic differences in perception of lung function: A factor in pediatric asthma disparities? Am J Respir Crit Care Med 182:12–18, 2010.
15. Crapo RO, Casaburi R, Coates AL, et al.Guidelines for methacholine and exercise challenge testing-1999. This official statement of the American Thoracic Society was adopted by the ATS Board of Directors, July 1999. Am J Respir Crit Care Med 161:309–329, 2000.
16. Miller MR, Hankinson J, Brusasco V, et al. Standardisation of spirometer. Eur Respir J 26:319–338, 2005.
17. Nathan RA, Sorkness CA, Kosinski M, et al. Development of the Asthma Control Test: A survey for assessing asthma control. J Allergy Clin Immunol 113:59–65, 2004.
18. Kinsman RA, Luparello TJ, O'Banion K, and Spector S. Multidimensional analysis of the subjective symptomatology of asthma. Psychosom Med 35:250–267, 1973.
19. Ritz T, Bobb C, Edwards M, and Steptoe A. The structure of symptom report in asthma a reevaluation. J Psychosom Res 51:639–645, 2001.
20. Zigmond AS, and Snaith RP. The hospital anxiety and depression scale. Acta Psychiatr Scand 67:361–370, 1983.
21. Kullowatz A, Kanniess F, Dahme B, et al. Association of depression and anxiety with health care use and quality of life in asthma patients. Respir Med 101:638–644, 2007.
22. Faul F, Erdfelder E, Lang A-G, and Buchner A. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods 39:175–191, 2007.
23. Tabachnick BG, and Fidell LS. Discriminant Analysis Using Multivariate Statistics. Boston, MA: Pearson Education, Inc., 375–436, 2007.
24. Schatz M, Zeiger RS, Yang SJ, et al. The relationship of asthma impairment determined by psychometric tools to future asthma exacerbations. Chest 141:66–72, 2012.
25. Trochtenberg DS, and BeLue R. Descriptors and perception of dyspnea in African-American asthmatics. J Asthma 44:811–815, 2007.
26. Krishnan JA, Diette GB, Skinner EA, et al. Race and sex differences in consistency of care with national asthma guidelines in managed care organizations. Arch Intern Med 161:1660–1668, 2001.
27. Wechsler ME, Castro M, Lehman E, et al. Impact of race on asthma treatment failures in the asthma clinical research network. Am J Respir Crit Care Med 184:1247–1253, 2011.
28. Leong AB, Ramsey CD, and Celedon JC. The challenge of asthma in minority populations. Clin Rev Allergy Immunol 43:156–183, 2012.
29. Thomsen DK, Mehlsen MY, Viidik A, et al. Age and gender differences in negative affect—Is there a role for emotion regulation? Pers Individ Dif 38:1935–1946, 2005.
30. Becklake MR, and Kauffmann F. Gender differences in airway behaviour over the human life span. Thorax 54:1119–1138, 1999.
31. Dirks JF, Fross KH, and Evans NW. Panic-fear in asthma: Generalized personality trait vs. specific situational state. J Asthma Res 14:161–167, 1977.
32. Kinsman RA, Dahlem NW, Spector S, el al. Observations on subjective symptomatology, coping behavior, and medical decisions in asthma. Psychosom Med 39:102–119, 1977.
33. Kinsman RA, Spector SL, Shucard DW, and Luparello TJ. Observations on patterns of subjective symptomatology of acute asthma. Psychosom Med 36:129–143, 1974.
34. Gavin LA, Wamboldt M, Brugman S, et al. Psychological and family characteristics of adolescents with vocal cord dysfunction. J Asthma 35:409–417, 1998.
35. Mobeireek A, Alhamad A, Al-Subaei A, and Alzeer A. Psychogenic vocal cord dysfunction simulating bronchial asthma. Eur Respir J 8:1978–1981, 1995.
36. Ekici A, Ekici M, and Bulcun E. Affect status and perception of exacerbation in patients with asthma. Allergy Asthma Proc 31:106–110, 2010.
37. Deshmukh VM, Toelle BG, Usherwood T, et al. Anxiety, panic and adult asthma: A cognitive-behavioral perspective. Respir Med 101:194–202, 2007.
38. Katon WJ, Richardson L, Lozano P, and McCauley E. The relationship of asthma and anxiety disorders. Psychosom Med 66:349–355, 2004.
39. Carr RE, Lehrer PM, and Hochron SM. Predictors of panic-fear in asthma. Health Psychol 14:421–426, 1995.
40. Roche N, and Godard P. Control and severity: Complementary approaches to asthma management. Allergy 62:116–119, 2007. □